TITLE: Testing a new satellite-image analysis technique to monitor pest related-, fire-, and post-fire-mortality in the Northwest Forest Plan area of Oregon
LOCATION: All eastside forestlands within Northwest Forest Plan area in the state of Oregon
DURATION: Year 1 of 2-year project **FUNDING SOURCE:** EM Fire Plan
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COOPERATORS: Robert Kennedy, Yang Zhiqiang, Oregon State University
FHP Sponsor/contact: Beth Willhite (R6) and Keith Sprengel (R6)

PROJECT OBJECTIVES: 1. Determine the appropriate spatial and temporal grain at which the LandTrendr algorithms can create maps that complement and augment FHM aerial surveys in monitoring severity and trends in pest-related mortality. 2. Utilize derived maps to examine relationships between mortality caused by pest epidemics, post-epidemic community change, wildfire, post-fire management, and post-fire vegetation response to build foundations for future predictive modeling.

JUSTIFICATION:
Significance and priority issues: Tree mortality caused by pest epidemics has long been thought to increase risk of subsequent wildfire, but recent studies have shown the relationships to be far more nuanced and situation-specific than previously assumed. In addition to short and medium-scale climatic conditions, pest agent, forest type and age, time since pest outbreak, and post-outbreak vegetation dynamics likely all contribute to variation in fire dynamics and risk over space and time (Bebi et al. 2003; Kulakowski and Veblen 2007; Kulakowski et al. 2003; Romme et al. 2006; Sibold et al. 2007). If pest epidemics and fire activity in the western U.S. change as expected under climate change scenarios (Hicke et al. 2006; Logan et al. 2003; Westerling et al. 2006), then greater understanding of the interactions between these two disturbance agents will be required to meet two goals of the National Fire Plan: rehabilitation of damaged landscapes and reduction of fire risk to rural communities. The former goal requires long-term monitoring of management effects, while the latter requires effective spatially-explicit modeling of fire risk and fuel loads. Both must be built on an understanding of pre- and post-pest and fire vegetation dynamics.

To meet both goals, spatial and temporally consistent maps of pest mortality, fire severity, and post-fire vegetation dynamics must be mapped across a range of forest type, climatic, and management regimes. While the Forest Health Monitoring (FHM) and the Monitoring Trends in Burn Severity (MTBS) programs produce maps that meet portions of these goals, no spatially and temporal consistent measurement tool exists to capture the full suite of dynamics related to pest, fire, and management. This gap must be filled if spatially-explicit monitoring and modeling of fire and pest dynamics are to be improved.

Basis and Feasibility We propose to investigate the extent to which our LandTrendr (Landsat Detection of Trends in Disturbance and Recovery) algorithms can meet these mapping needs and lay foundations for predictive modeling of pest-related fuel loading and risk. LandTrendr grew out of a trajectory-based change detection approach summarized in Kennedy et al. (2007) that leverages yearly "stacks" Landsat Thematic Mapper imagery to map dynamics. It represents a fundamentally new approach to mapping that allows explicit capture of full landscape dynamics, not simply disturbance events, and allows for much greater capture of the subtle effects of low-level pest mortality. We are using LandTrendr to develop yearly maps of thinning, clearcuts, and fires within the area of the Northwest Forest Plan (NWFP; Contact: Melinda Meour, PNW Research Station), and the work we propose here will build from the substantial foundational processing and analysis that is being conducted under that project.

Linkage with FHM: While our maps will not ascribe agent (type of pest), the maps expected from this project complement FHM data in their greater spatial detail and temporal and spatial consistency, allowing modelers far greater specificity in relating driving variables (topographic, vegetation type, soil) to actual severity of pest mortality. Additionally, they simultaneously measure pest, fire, and post-fire harvest recovery dynamics on the same intensity scale, setting the stage for better spatially-explicit modeling of fire risk. This could provide objective means of identifying foci for allocation of limited resources, and could aid in reducing harm to rural communities.

DESCRIPTION: Background: Detection of subtle pest effects using Landsat imagery has been shown to be feasible with Landsat TM data (Royle and Lathrop 2002; Skakun et al. 2003; Townsend et al. 2004; Wulder et al. 2006), but it has long been recognized that separation of subtle effects from background noise is difficult when deriving such maps from two dates of imagery alone (Wulder et al. 2005). The trajectory approach utilizes more than 20 years of yearly imagery to markedly increase the signal-to-noise ratio and thereby better separate subtle effects from noise caused by phenological and sun illumination angle across seasons (Kennedy et al. 2007). For example, initial investigations comparing LandTrendr outputs to FHM data show that LandTrendr algorithms successfully detect and map both defoliator (spruce budworm, Figure 1) and bark beetle mortality (not shown) in both mid-elevation mixed conifer forest and in pine forests.

Methods: *Image processing and GIS analysis:* We will extract signals of slow vegetation degradation from our raw LandTrendr outputs already completed by the end of this calendar year. Objective 1 focuses on comparing these outputs to FHM overflight data, and will involve analysis designs that vary both temporal and spatial grain of both LandTrendr and FHM data to understand scales of maximum agreement. These will then be used to develop maps of pest mortality at a new spatial and temporal grain for the entire east-side forests in the Oregon NWFP area. A directed field sampling campaign in summer 2009 will use a stratified design to confirm predicted combinations of pest mortality, fire, and post-fire recovery variability. Objective 2: LandTrendr outputs will be linked with forest cover maps developed for the NWFP monitoring program using the GNN approach (Ohmann and Gregory 2002; Ohmann et al. 2007) to evaluate effects of forest type and age on pest and fire. We will also use daily fire progression maps to examine whether initial location of eventual large fires is related to particular pre-fire dynamics. These relationships will be evaluated for correlative relationships using standard multivariate approaches to uncover potential commonalities in either pre-fire vegetation dynamics or post-fire recovery dynamics.

Products: 1. Landsat-based maps of cumulative pest-related tree mortality across east-side Cascade forests for the entire NWFP area of Oregon from 1985 to 2007. These will represent a unprecedented spatially and temporally consistent measure of pest mortality at the regional scale. 2. Statistical (correlative) models relating pest activity, fire risk, and post-fire mortality and recovery dynamics, to set the stage for future hypothesis-driven modeling to improve fire-risk and fuel-load modeling.

Timeline: January-June 2009: Objective 1: Extraction of pest mortality signatures from LandTrendr outputs; Linkage to FHM overflight data. June-October 2009: Field examination of stratified samples of forest type, pest mortality, and fire dynamics. October 2009-April 2010: Objective 2: Analysis of interactive effects among predictor variables, development of predictive statistical models, and submission of peer-reviewed reports/papers on all efforts.

Costs:

		Item	Requested FHM EM Funding	Other source funding	Source
YEAR: FY 2009	Administration	Salary (1)	$31,067	$34,500	PNW Research Station, Oregon State University
		Overhead			
		Travel (2)	$6,000		
	Procurements	Contracting			
		Equipment (3)	$2,000		
		Supplies (4)	$400		
	Total		$39,467	$34,500	
YEAR: FY 2010	Administration	Salary (5)	$31,999	$35,535	PNW Research Station, Oregon State University
		Overhead			
		Travel (6)	$1,000		
	Procurements	Contracting			
		Equipment			
		Supplies (7)	$1,500		
	Total		$34,499	$35,535	

1 $18000: 4 months of research assistant time (36000 annual plus OPE);
$13067: 2 months postdoc salary (56000 annual salary plus OPE)
Other source funding: in kind salary support for Cohen ($15750, 1 month)
and Kennedy ($18750, 2 months)

2 Field work

3 Computer for field data collection and entry

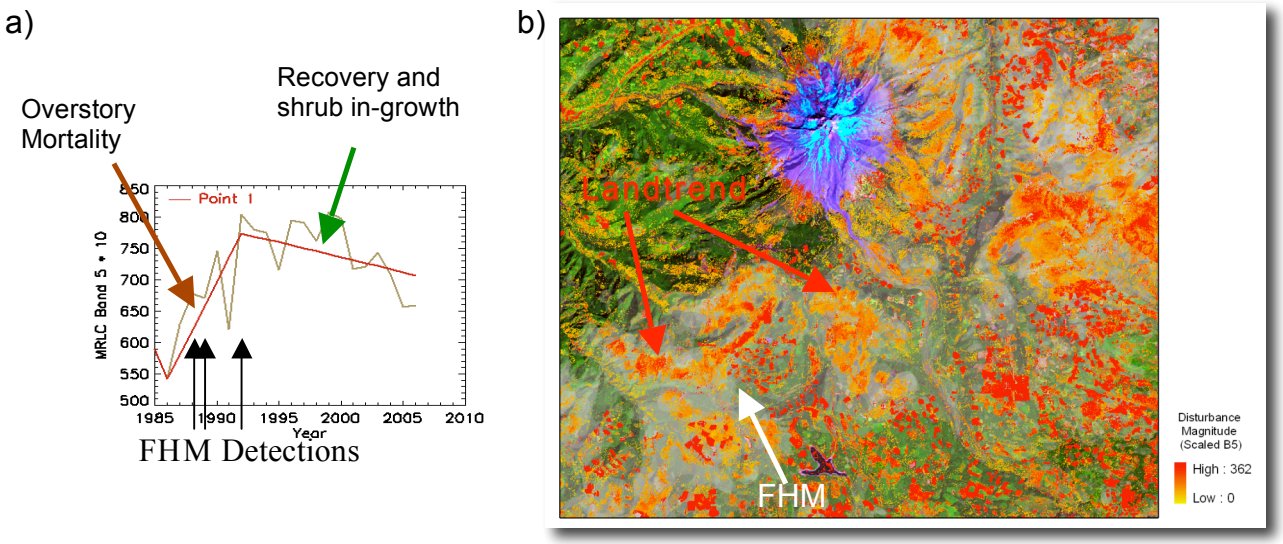
4 Misc field supplies

5 Same as (1) above, with 3% salary raise included

6 meetings/presentations

7 publication cost

Figure 1. LandTrendr detection of pest dynamics. a) Pest-related mortality results in multi-year signal in satellite record that is captured through pixel-by-pixel fitting of trajectories (red line). b) Maps of the intensity of disturbance near Mt. Hood, OR, overlaid on FHM polygon data. LandTrendr disturbance magnitude in orange and red tones; FHM occurrence underneath LandTrendr in white. In this case, FHM data are for all years from 1985 to 1992, with transparent overlays that result in greater opacity when FHM polygons detect activity for multiple years.



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